VARIATION PATTERNS IN FOUR CLONES OF MERTENSIA CILIATA[1]

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Mertensia ciliata (James) G. Don is well delineated from other species of the genus in the monograph by Williams (1937). Field observations in the area of the present study, Gunnison County, Colorado, bear out this distinctness of *M. ciliata* from other sympatric species, although considerable intraspecific variation is easily detected. In spite of the fact that certain other species of the group grow sympatrically in the study area with *M. ciliata,* five years of observation by the author have not uncovered a single likely instance of hybridization between *M. ciliata* and any of the other species. Nor did artificial cross pollination produce any fertile seed between *M. ciliata* and *M. fusiformis* Greene. In the observed populations, therefore, *M. ciliata* seems an excellent species in which to study quantitatively intraspecific variation patterns which are probably uncomplicated by any present inflow of genes from another species. With this objective in mind, three floral characteristics within and among four clones of *M. ciliata* were chosen for study. The clones were selected such that each was separated from the other by a distance of one-third to two miles. Such a distance probably assures that each clump is an individual clone with a different genetic origin. Hence the four clumps will be referred to hereafter as clones A, B, C, and D. Since each clone was growing in a different combination of environmental factors, at least four of the many micro-habitats to which individuals of *M. ciliata* are adapted are represented. By selecting clones in the above manner, it was presumed that a measure of somatic variability could be obtained, since the phenotypic measurements would be made upon single genotypes each produced in a slightly different environment. In addition, differences in gene expression among the clones imply possible genetic variation patterns.

METHODS AND RESULTS

Clones A, B, C, and D were collected in the summer of 1953 in or near the Rocky Mountain Biological Laboratory, Gunnison County, Colorado. No clone was nearer than approximately one-third mile from another, and all clones were located on different drainage channels. The altitude is approximately 9,500 feet for three of the clones and 10,000 feet for Clone B. Voucher specimens of the collections are in the personal herbarium of the author.

Length of calyx, corolla-tube, and corolla-limb were measured from these herbarium voucher specimens. In this study the corolla-limb, as defined by Williams (1937), will include that portion of the corolla above the fornices. Individual mature flowers were measured for the three floral characteristics to 0.5 mm. using low power of a binocular microscope to

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TABLE 1. Arithmetic mean, standard deviation, and range of variation for length of calyx, corolla-tube, and corolla-limb in four clones of *Mertensia ciliata*

Clone	No. of Individuals	Calyx Length			Corolla Tube Length			Corolla Limb Length		
		Mean	Standard Deviation	Range of Variation	Mean	Standard Deviation	Range of Variation	Mean	Standard Deviation	Range of Variation
A	150	2.5	0.24	2.0–3.5	5.4	0.52	3.5–6.5	5.9	0.70	4.5–8.0
B	94	1.8	0.30	1.5–2.5	6.2	1.51	5.0–7.5	7.3	1.04	5.0–9.5
C	132	1.8	0.33	1.5–2.5	6.8	0.50	5.5–8.0	6.1	0.88	4.0–8.0
D	40	2.1	0.30	1.5–2.5	5.9	0.36	5.0–6.5	7.1	0.79	5.0–9.0

increase accuracy. Arithmetic mean, standard deviation, and range of variation were determined for each characteristic measured in the four clones. These results are presented in Table 1. In Figure 1 variation among the four clones is diagrammed using mean length of calyx, corolla-tube and corolla-limb. Range of variation within the clones is diagrammed in Figure 2.

Descriptions of the clones are as follows:

CLONE A. Collected July 15 from a moist roadside site one-fourth mile north of the laboratory. The clump was growing on the edge of a dense willow thicket in full sun. There was a total of 14 individual stems in the clone, averaging 10.7 mature flowers per stem. Total number of mature flowers measured was 150.

CLONE B. Growing in a very wet location in the partial shade of a spruce-fir forest on the edge of a beaver pond about two miles northeast of the laboratory at 10,000 feet and collected on July 19. The average number of mature flowers was 3.1 on a total of 30 individual stems; 94 mature flowers were measured.

CLONE C. Chosen from a population in an aspen forest on laboratory property. The clone was collected on July 23 in a partially shaded rocky stream bed. This clone had 32 stems, the largest number of individual stems of the four clones. Average number of mature flowers per stem was 4.1; 132 mature flowers were measured from this clone.

CLONE D. Growing in a willow thicket near Copper Creek adjacent to the laboratory. The soil was wet and rocky, the clone growing in partial shade. Collection was on July 7. The three individual stems of this clone, all flowering, averaged 13.3 mature flowers per stem and totaled 40 mature flowers suitable for measurement.

DISCUSSION

The variation pattern for each of the four studied clones of *Mertensia ciliata* is striking enough that a given clump can be identified on the basis of a distinctive combination of average length of calyx, corolla-tube and corolla-limb (fig. 1). On the other hand, individual measurements within

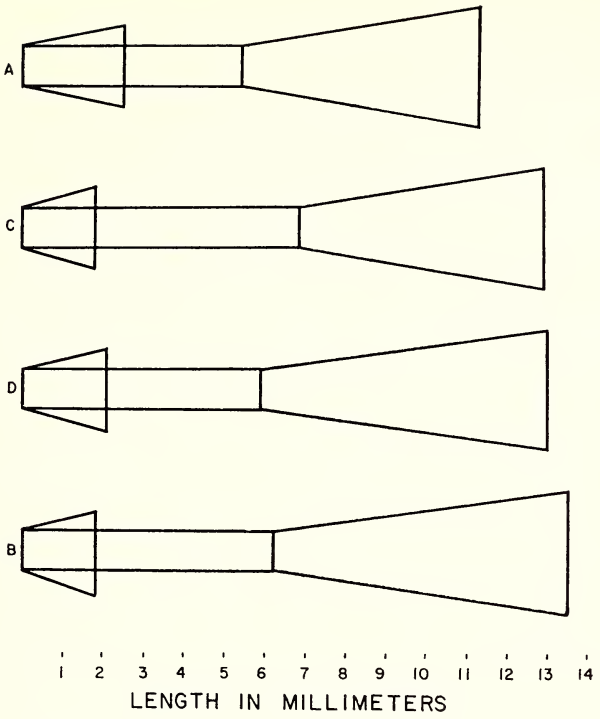

Fig. 1. Idiograms showing average lengths in millimeters of calyx, corolla tube, and corolla limb in clones A, B, C, and D of *Mertensia ciliata*.

each clone vary considerably for these three characteristics (fig. 2). However, the range of variation of a character in a clone usually does not overlap completely with that of the same character in other clones. These observed variations within and among the clones could be the result of three factors mentioned by Stebbins (1950): environmental modification, gene recombination, and mutation of genes or chromosomes. Considerations of the role of these factors as possible explanations for the variability observed is discussed in the following.

Environmental Modifications. Variability within a given clump should be a measure of environmental influences except for rare bud mutations or the unlikely possibility that one clump was derived from two or more seedlings. Floral characteristics were chosen for study because they are known to be frequently less easily influenced by environmental factors than are many vegetative characteristics (Clausen, Keck, and Hiesey, 1940; Anderson, 1929; Brainerd and Peitersen, 1920). All three characteristics vary considerably in range of measurements within each clone, such as the 1.5 mm. variation in Clone A calyx length which averages only 2.5 mm., the 3 mm. variation in corolla tube length in Clone

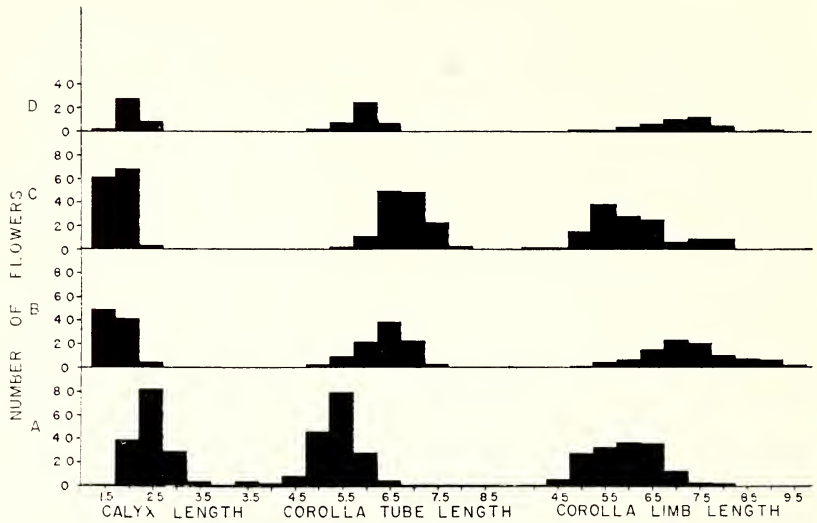

FIG. 2. Histograms showing distribution of individual measurements in millimeters of length of calyx, corolla tube, and corolla limb in clones A, B, C, and D of *Mertensia ciliata*.

A which averages 5.4 mm. in length, or the 4.5 mm. variation in corolla limb length for Clone B while average length is only 7.3 mm. This indicates that gene action, even in the fairly uniform environment of a single clone, differs in the final expression of length of calyx and corolla. To determine the various environmental factors that control the diverse action of these genes is difficult even in the imagination. External conditions such as soil, temperature, light, humidity, and biotic interactions would usually be expected to vary comparatively slightly during the development of the flower primordia of a single clump. Internal conditions such as amount and distance of the vascular supply, internal temperature, chemical environment, and the differing interaction of other genes in ontogeny would perhaps be more important than external environment since a slight variation of internal environment during the delicate interactions between gene initiation and the end result of expression could alter the phenotype. Whichever of the external or internal conditions may be important, their effect on the genes controlling calyx and corolla length accounts for a large proportion of the variation observed in this study, probably all of the intraclonal variability. This would support the idea that corolla and calyx length in this case are quantitative characteristics, dependent on multiple genes, since quantitative characteristics are usually subject to considerable modification by environment (Srb and Owen, 1952).

GENE RECOMBINATION AND MUTATION. While the somatic variation discussed above cannot result in permanent changes in the species, gene

recombination and/or gene and chromosomal mutation are thought to contribute to variation that can foster evolutional change in the species (Stebbins, 1950). Whether gene recombination and mutations could account for the differences among these four clones cannot be determined from the results of this study. Probably some of the observed differences among clones would be attributed to dissimilarities in external or internal environments of the four clones. It must be noted again, however, that floral characteristics are probably less subject to environmental modification than are other features of external morphology. Floral differences based on the pattern of average length of calyx, corolla-tube, and corolla-limb illustrate a distinctive combination in each clone (fig. 1). On close examination of the individuals compounded in these means it is found that only a few flowers approach the extremes of the large range of variation, and that standard deviations, given in Table I, are not large. Also, the histograms for each clone do not closely coincide with those for the other clones, although considerable overlapping does occur (fig. 2). These patterns of difference among the clones are probably the result of gene recombination, mutation because of its rarer occurrence being a less likely source. If *Mertensia ciliata* has a large number of genes active in regulating corolla length, such as the estimated twelve or more controlling corolla size in *Nicotiana* (Smith, 1937), it would be plausible to assume such recombination of the many genes in different individual plants or clones. Close linkage between the polygenes that determine quantitative characteristics, however, is often assumed to restrict the range of recombination of characteristics (Smith, 1944). Nevertheless, while somatic variation is doubtless the main factor in accounting for the variation within each clump, the characteristic variation patterns presented here for calyx and corolla length would imply some genetic differences among the clones, probably, as a result of gene recombination.

Summary

Length of calyx, corolla-tube, and corolla-limb were measured for four widely separated clumps, presumably clones, of *Mertensia ciliata* that were collected from four differing and widely separated sites in Gunnison County, Colorado. Comparisons of calyx and corolla lengths were made within and among the four clones. The considerable variation of the three characteristics found within each of the clones is attributed to external and internal environmental factors, internal conditions probably being more important. Variation patterns among the clones differ enough to give each clone a distinctive combination of average lengths for the three characteristics. In most cases, the range of variation in calyx and corolla length within each clone does not completely coincide with that of the other clones. These differences in variation patterns imply some genetic differences among the clones, probably as a result of gene recombination.

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NEW COMBINATIONS IN ASTER

Roxana S. Ferris

Through an inadvertence the following new combinations were not legally made in the recent "Flora of the Marshes of California" by Herbert L. Mason.

Aster occidentalis var. **parishii** (Gray) Ferris, comb. nov. *A. fremontii* var. *parishii* Gray, Syn. Fl. N. Amer. 1 (2): 192. 1884.

Aster occidentalis var. **delectabilis** (H. M. Hall) Ferris, comb. nov. *A. delectabilis* H. M. Hall, Univ. Calif. Publ. Bot. 3:82. 1907.

Both of these varieties occur in California in the Sierra Nevada and in the mountains of southern California, and they reoccur in the San Pedro Mártir of northern Baja California, Mexico.

Dudley Herbarium, Stanford University,
Stanford, California.

NOTES AND NEWS

Some publications of interest follow:

Under the auspices of the *Gobierno del Estado de México, Dirección de Recursos Naturales* (Toluca) publications on the *Flora del Estado de México* have continued to appear. During 1958 Professor Maximino Martínez completed the *Flora Medicinal* as well as the treatment of the Cactaceae and some forty smaller families; Professor Eizi Matuda treated the Gramineae, Umbelliferae and the Compositae.

Drawings of British Plants, by Stella Ross-Craig. Part XI. Droseraceae—Ficoidaceae. 39 pls. 1958, 9s. 6d. G. Bell and Sons, Ltd. London. Part XII. Umbelliferae (1). 36 pls. 1958. 9s. 6d. 1958.